Universality of supernova $\gamma$-process

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The scaling empirical law between $p$-nuclei and $s$-nuclei were found in the solar abundances and it indicated a novel concept of the universality of the supernova $\gamma$-process [1,2]. Using core-collapse supernova explosion models, we investigate the principle of the universality that the $s/p$ abundance ratios produced by individual supernova $\gamma$-processes are almost constant over the wide region of atomic number. The universality originates from three mechanisms, the weak $s$-process in pre-supernovae, the independence of the $s/p$ abundance ratios of the nuclear reactions, and the shift of the $\gamma$-process layers. Our calculations further suggest an extended universality that the $s/p$ ratios in the $\gamma$-process layers are not only constant but also centered around a specific value of 3. The scaling is also a piece of evidence that the weak $s$-process occurs in massive stars before the supernova explosions.

References